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Engineering Development of the Mechanical Heart-Pump

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1. The need to be filled.

The role of cardiovascular failure as the principal cause of death is too well known to need reminding. Nor is it always associated with advanced age and deterioration of other faculties. Many hundreds of thousands of Americans still in their prime of life and often at a stage in their career when they can still make their most important contributions to the progress of the community are mown down or disabled every year by an accident to an organ that is, after all, only a pump for the circulation of the blood. Apart from the crises of heart failure, cardiac inadequacy may have much wider ramifications. Starting from the time of birth and earlier, even the momentary failure of the supply of blood to the brain can impose penalties at every level on its normal development and functioning. Cardiac function is also a limiting factor in some "normal" performance, not only athletics, but many arduous tasks in industry and in military service that demand unusual muscular output.

An artificial heart could not of course take the place of a healthy cardiovascular system. In many individuals the failure of the heart may be only the most crucial aspect of general disease which involves the whole circulation, and thereby also the brain, the kidneys and other vital organs. Replacement of the heart in advanced arteriosclerosis would be at best a palliative, and continued attack on the underlying metabolic degeneration must retain first priority. However, for most individuals the failure of cardiac function is the medical crisis; when this is met a reasonable level of health can often be retrieved, as is shown by the performance of many patients who survived their first attack and for whose vitality we rely on the recuperative powers of the

whole body, including the very damaged heart itself. This points to an important element in the staging of goals: a very useful benefit would result from an assistant (not replacement) heart: a device that took over only part of the normal function of the heart or for a limited time during which the natural heart might recuperate. In a special sense, this has already been brilliantly accomplished by the heart-lung apparatus used for open-heart surgery.

2. Investing in system development.

It is difficult to point to any fundamental reasons why a useful pump could not be designed just now. There are a multitude of separate problems - materials, energy supply and transfer, control, maintenance, servicing and reliability, and so forth - none of which appears to be beyond the reach of existing technology. That is to say, the necessary fundamental scientific information seems to be already available, or attainable through identifiable lines of work. The situation is thus analogous to the problem of orbiting a satellite, the feasibility of which had already been demonstrated by Goddard almost thirty years before it was done. And which once accomplished opened a whole new area of opportunity and concern.

Plainly we are dealing with a complicated system, too complex to be optimally designed by a single worker, and perhaps approaching one of the simpler military weapons systems in complexity (that is, I would think,much closer to a guided missile or a subsonic bomber than COMSAT or lunar exploration). But this is already so complex that the realistic definition of the problem requires a sophisticated engineering approach, which itself entails a substantial investment by the usual standards of health research. We have, however, seen many brilliant examples of this technique in defense and in space systems.

In consequence this country has built up a strong industrial competence in systems planning, which is after all quite different from academic research. We should then take full advantage of industrial potentiality for dealing with health problems, particularly at a time when defense requirements may have peaked out and, for example, the aerospace industry is not overloaded with military orders.

In many other equally pressing areas of health research, such as cancer or mental retardation and related developmental disorders, we simply do not yet have the basic scientific information to support a broad technological attack. The development of the surrogate heart should however be a prototype for many other advances in the use of sophisticated industrial technology for the health-security of the nation. Perhaps it is also more than a lucky accident that many pieces of advanced technology (such as compact energy sources) which have been developed for defense and space systems promise to have direct applications here.

3. Organ transplantation: an alternative approach?

The splendid progress of organ transplantation has of course raised the possibility of the use of a transplanted living heart as a substitute for a diseased one. I have no doubt as to the technical feasibility of this approach within the near future, which has already been demonstrated on a limited scale with experimental animals. However, I see very serious problems arising out of the very success: concretely, how we can arrange to provide for a supply of usable organs that can begin to match the potential demand. This balance is especially difficult for the heart, a vital unpaired organ (hence limited supply) and one subject to a prevalent disease (therefore extensive demand). What is already a formidable problem of ethical and social decision to men of the highest integrity and good will in the course of their pioneering medical inves-

tigations would be aggravated into a tacit competition subject to ugly pressures in an area where there is no ready consensus of moral judgment nor benefit of traditional experience.

I have no doubt we could learn to meet this problem with both technical and procedural advances, but it will take time towork out a harmonious system, and we ought to anticipate and minimize the stresses meanwhile. In addition, a substantial fraction of cases requiring cardiac assistance are not likely to tolerate the drugs for suppression of immunity that we foresee as the principal approach to the transplantation problem.

In this light, the approaching success of organ transplantation lends even more weight to the urgency of parallel efforts in the development of artificial organs.